

Oviposition site selection in *Oxyagrion microstigma* Selys, 1876 (Odonata: Coenagrionidae) is related to aquatic vegetation structure

Rhainer Guillermo-Ferreira^a and Kleber Del-Claro^{b*}

^aDepartamento de Biologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, SP, Brazil; ^bInstituto de Biologia, LECI, Universidade Federal de Uberlândia, Uberlândia, MG, Brazil

(Received 29 March 2011; final version received 2 September 2011)

Oviposition site selection is crucial in the life history of odonates since females must find a suitable habitat to enhance larval survival and development. Males perch at these sites to get access to females to mate. Here we studied how different types of vegetation influence site selection of the damselfly *Oxyagrion microstigma* in a Neotropical savanna pond. We identified and quantified the aquatic plants on the study site and investigated the relationship between plant species density, male site fidelity and female oviposition. The results showed that male density increased with higher densities of the Cyperaceae *Eleocharis* sp. but with lower densities of the Pontederiaceae, *Pontederia parviflora*. The number of males was also positively correlated with the number of ovipositing females and the duration of oviposition bouts. The females were found ovipositing on sites with *Eleocharis* sp., which was used as an oviposition substrate. We suggest that the species composition of aquatic vegetation in the environment, as well as the distribution and abundance of plants, can be a major determinant factor of damselfly habitat selection.

Keywords: dragonfly; damselfly; Zygoptera; *Oxyagrion*; habitat selection; oviposition

Introduction

Habitat selection is often related to survival and reproductive success, and a suitable habitat should contain resources that enhance reproduction (Orians & Wittenberger, 1991). For many invertebrates, habitat selection has been linked to oviposition site preference, which is a crucial factor for the survival and development of offspring (Bernardo, 1996; Jaenike & Holt, 1991; Mousseau & Fox, 1998; Yáñez & Floater, 2000).

In Odonata, oviposition can be endophytic (within plant tissues) or exophytic over the water surface or other substrates (Corbet, 1999). Since female reproductive success depends on survival of larvae, the females should carefully select the oviposition site (Fincke, 1992; Siva-Jothy & Hooper, 1995).

*Corresponding author. Email: delclaro@ufu.br



Figure 1. Male *Oxyagrion microstigma* perched on *Eleocharis* stem; photo cropped and sharpened slightly in Adobe Photoshop®.

The range of habitat selection depends on the species' size and mobility, and the structure of the environment (Jaenike & Holt, 1991). The presence of vegetation plays an influential role in habitat selection (e.g. Martens, 1992) because differences on vegetation structure may influence the distribution of odonates (Hofmann & Mason, 2005). Considering the low dispersal potential of many zygopterans (Conrad et al., 1999), the distribution of damselflies in the environment should depend on the distribution and type of vegetation substrates used for oviposition (Guillermo-Ferreira & Del-Claro, 2011; Martens, 2001).

In some species, the females are capable of detecting the resources that present the best micro-habitat for larval development, selecting specific plant species as oviposition substrate (e.g. Martens, 1992; Wildermuth, 1993). Males, in turn, usually perch in or near oviposition sites to get access to females (Corbet, 1999). Thus, here we studied the distribution of male *Oxyagrion microstigma* Selys (1876) (Figure 1) at a Neotropical savanna pond, and its relation to vegetation structure and oviposition site selection. We finally hypothesized that habitat selection depends on vegetation type and species.

Materials and methods

We conducted our study at a pond in the Ecological Reserve of the “Clube de Caça e Pesca Itororó de Uberlândia” (CCPIU), Uberlândia, Minas Gerais state, Brazil (15° 57' S, 48° 12' W; altitude 863 m; 640 ha; for details see Arruda et al., 2006). This pond can be classified as a lentic reproductive site, with open exposure, perennial, with vegetation <0.50 m and aquatic vegetation (submerged, floating and emergent types). We divided the borders into three 10-m² transects

consisting of plots of 10 1-m² squares. Since males were found in only one border, all data presented here refer only to the single transect where damselflies were found. We took pictures of each square and classified them according to the vegetation structure. We identified two species of aquatic plants on the squares, *Pontederia parviflora* (Figure 2a) and *Eleocharis* sp. (Figure 2b). We classified each square on a scale of density of 1 to 4 for each plant species as follows: (1) few or none, (2) low density, (3) medium density, (4) high density. The replicability of this method was tested by asking two different persons to classify the pictures according to this scale. The two persons never knew the scores the other person chose. The method showed high replicability for both *P. parviflora* ($r = 0.9126$; $p = 0.0002$) and *Eleocharis* sp. ($r = 0.9633$; $p = 0.000008$).

On five different days in August and September 2006, we captured and marked males at the squares to quantify how many males were found within each site. Additionally, we searched for males in the vegetation around the pond to see if they were found only at the water. We also quantified the number of ovipositing females at each square and the oviposition time spent on each site. We then tested the relationship between the number of males and the number of ovipositing females and the oviposition duration using the Spearman rank correlation test. We also made behavioral observations of *O. microstigma* males, which are presented here following the classifications by Corbet (1999) and Martens (2003). The behavior classified here as threat display consist of a wing spreading display that causes the rival male to retreat (Corbet, 1999).

Results

General behavior

We captured a total of 21 males. Males arrive earlier at the pond and show site fidelity, clustering in a small section of the pond and perching on oviposition sites. Males usually returned to the same site on 1.66 ± 1.19 days (range 1–5 consecutive days) and occupied a single site during the day. No male was found away from the water and matings always occurred at the oviposition sites when the females approach the water to mate with males. Males are perchers and fly only to chase other males or to patrol the site searching for females. Male–male interactions can be considered aggressive, since they were indifferent to conspecific males in five (3%) cases, chased off the rival in 117 (78%) cases, made a threat display in eight (5%) cases and grabbed the rival in 20 (13%) cases. After a pursuit, the male intruder perched away while the other male returned to his former stem. Males fought even in the absence of females at the oviposition site.

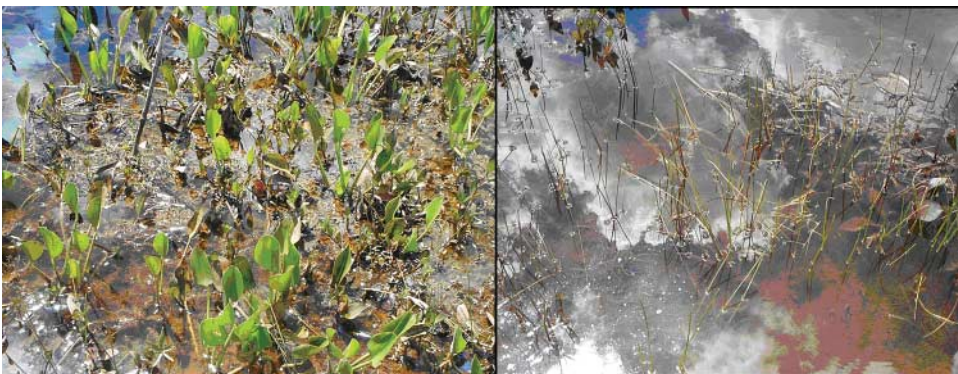


Figure 2. Plant species present in the habitat of *Oxyagrion microstigma*: (a) *Pontederia parviflora*, and (b) *Eleocharis* sp.

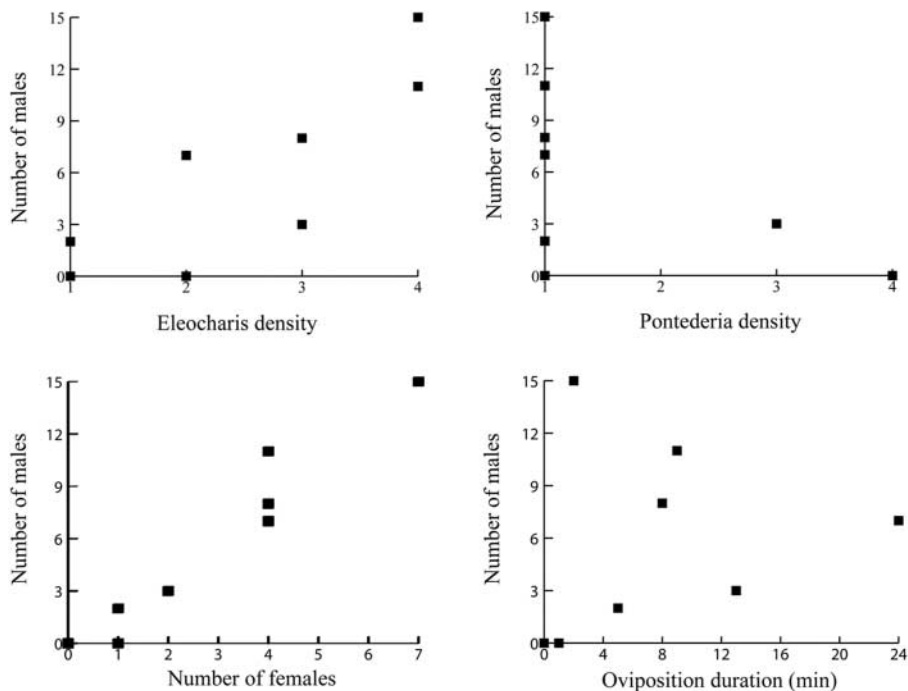


Figure 3. The relationship between the number of males of *Oxyagrion microstigma* captured and (a) the density of *Eleocharis* sp., (b) the density of *Pontederia parviflora*, (c) the number of ovipositing females, and (d) the duration of ovipositions.

Habitat selection

The males were captured in sites with more *Eleocharis* sp. (Figure 3a; Spearman rank correlation coefficient, $r_s = 0.86$; $p = 0.001$; $n = 10$), but with less *P. parviflora* (Figure 3b; $r_s = -0.68$; $p = 0.03$; $n = 10$). The males also were found in areas where more females were seen ovipositing (Figure 3c; $r_s = 0.95$; $p = 0.00001$; $n = 10$) and where females oviposited for longer periods (Figure 3d; $r_s = 0.69$; $p = 0.02$; $n = 10$). We observed 23 ovipositions in tandem on *Eleocharis* sp. but none on *P. parviflora* or any other substrate. No female was ever seen ovipositing alone. The couple may submerge during oviposition, which seems to be endophytic. Oviposition occurred immediately after mating, both usually occurring at the same square where the male was perched and surrounding *Eleocharis* stems. Mating and oviposition occurred in an estimated area between 1 and 2 m². After oviposition, the males typically returned to their original perch.

Discussion

It is known that aquatic vegetation structure can influence the distribution of odonate species (Hofmann & Mason, 2005). Our results showed that *O. microstigma* males occupy patches dominated by the plant *Eleocharis* sp., and they behave aggressively toward conspecific males that approach closely. *Eleocharis* is also used by females as their predominant, if not exclusive, oviposition substrate. The distribution of this damselfly in this pond may have a singular relationship with this plant species, since the abundance of this plant largely determined the distribution of individuals in the environment. However, the damselfly distribution may also be influenced by the presence of *P. parviflora*, which was not defended by males and was not used by females.

Possibly *O. microstigma* avoids this plant because it forms a dense root mass which may not be a good micro-habitat for larvae.

We showed here that *O. microstigma* males prefer to perch on oviposition sites with exclusive characteristics that may be selected by females to enhance larvae survival (Fincke, 1992; Siva-Jothy & Hooper, 1995). Males probably exhibit a female-control system, because females arrive at the oviposition site to mate, just where males hold and apparently compete for perches that provide good vantage points for detecting and intercepting approaching females (Conrad & Pritchard, 1992). We suggest here that the distribution of aquatic plant species may have a strong effect on the distribution patterns of damselflies as well as their abundance.

Acknowledgements

We thank Andreas Martens and Michael L. May for an extensive review of the original manuscript. RGF and KDC (PQ/AT/IC) thank CNPq for financial support. KDC also thanks CAPES (Research grant).

References

- Arruda, R., Carvalho, L.N., & Del-Claro, K. (2006). Host specificity of a Brazilian mistletoe, *Struthanthus* aff. *polyanthus* (Loranthaceae), in cerrado tropical savanna. *Flora*, 201, 127–134.
- Bernardo, J. (1996). The particular maternal effect of propagule size, especially egg size: patterns, models, quality of evidence and interpretation. *American Zoologist*, 36, 216–236.
- Conrad, K.F., & Pritchard, G. (1992). An ecological classification of odonate mating systems: the relative influence of natural, inter and intra-sexual selection on males. *Biological Journal of the Linnean Society*, 45, 255–269.
- Conrad, K.F., Willson, K.H., Harvey, I.F., Thomas, C.J., & Sherratt, T.N. (1999). Dispersal characteristics of seven odonate species in an agricultural landscape. *Ecography*, 22, 524–531.
- Corbet, P.S. (1999). *Dragonflies: Behavior and ecology of Odonata*. Ithaca, NY: Comstock.
- Fincke, O.M. (1992). Consequences of larval ecology for territoriality and reproductive success of a Neotropical damselfly. *Ecology*, 73, 449–462.
- Guillermo-Ferreira, R., & Del-Claro, K. (2011). Resource defense polygyny by *Hetaerina rosea* Selys (Odonata: Calopterygidae): Influence of age and wing pigmentation. *Neotropical Entomology*, 40, 78–84.
- Hofmann, T.A., & Mason, C.F. (2005). Competition, predation and microhabitat selection of Zygoptera larvae in a lowland river. *Odonatologica*, 34, 27–36.
- Jaenike, J., & Holt, R.D. (1991). Genetic variation for habitat preference: Evidence and explanations. *American Naturalist*, 137(Suppl.), 67–90.
- Martens, A. (1992). Egg deposition rates and duration of oviposition in *Platycnemis pennipes* (Pallas) (Insecta, Odonata). *Hydrobiologia*, 230, 63–70.
- Martens, A. (2001). Initial preference of oviposition sites: discrimination between living and dead material in *Sympecma fusca* and *Coenagrion caerulescens* (Odonata: Lestidae, Coenagrionidae). *European Journal of Entomology*, 98, 121–123.
- Martens, A. (2003). Reproductive behavior of African Odonata – a review. *Cimbebasia*, 18, 225–241.
- Mousseau, T.A., & Fox, C.W. (1998). The adaptive significance of maternal effects. *Trends in Ecology and Evolution*, 13, 403–407.
- Orians, G.H., & Wittenberger, J.F. (1991). Spatial and temporal scales in habitat selection. *American Naturalist*, 137(Suppl.), 29–49.
- Siva-Jothy, M.T., & Hooper, R.E. (1995). The disposition and genetic diversity of stored sperm in females of the damselfly *Calopteryx splendens xanthostoma* (Charpentier). *Proceedings of the Royal Society of London (B)*, 259, 313–318.
- Wildermuth, H. (1993). Habitat selection and oviposition site recognition by the dragonfly *Aeshna juncea* (L.): an experimental approach in natural habitats (Anisoptera: Aeshnidae). *Odonatologica*, 22, 27–44.
- Yáñez, M. & Floater, G. (2000). Spatial distribution and habitat preference of the endangered tarantula, *Brachypelma klaasi* (Aranae: Theraphosidae) in Mexico. *Biodiversity and Conservation*, 9, 795–810.